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(54) Title of Invention: **CONTACT EXPOSURE SYSTEM**

(57) Abstract

PURPOSE: To provide a contact exposure system that reduces the film thickness of an immersion liquid that is interposed between a wafer and a photomask or a projection optical system, thereby reducing the amount of light absorbed and reducing and preventing exposure unevenness.

CONSTITUTION: A wafer 3, which is coated with a photoresist 4, is brought into close contact with an exposure lens 2 through an immersion liquid 5. A surfactant 11 is mixed into the immersion liquid 5 within a range that does not affect the photoresist 4, thereby reducing the surface tension and increasing the wettability of the immersion liquid 5. Accordingly, the film thickness d_2 of the immersion liquid is reduced more than the case wherein the surfactant is not mixed in.

CLAIMS

1. A contact exposure apparatus that brings a wafer, which is coated with a photoresist, into close contact with a projection optical system or a photomask through an immersion liquid, and then transfers a pattern of the photomask to the photoresist by irradiating an irradiation light, wherein

> a surfactant is mixed into the immersion liquid within a range that does not affect the photoresist.

DETAILED EXPLANATION OF THE INVENTION

[0001]

INDUSTRIAL FIELD OF APPLICATION

The present invention relates to an exposure apparatus that projects and exposes a pattern of a photomask onto a wafer in an LSI fabrication process, and more particularly relates to a contact exposure apparatus.

[0002]

RELATED ART

With the kind of exposure apparatus that irradiates laser light and the like to project and expose the pattern of a photomask onto a semiconductor substrate, such as a silicon wafer, by using a projection optical system, four exposure systems are known: (1) a contact exposure system, (2) a proximity exposure system, (3) a reflection type projection exposure system, and (4) a reduction lens projection exposure system.

[0003]

Among these systems, the contact exposure system performs exposure by bringing the photomask (or the projection optical system) and the wafer into close contact, and the wavelength within the photoresist therefore is reduced by a factor of the inverse of the refractive index if they are completely in contact; consequently, the impact of diffraction is small and a high resolution transfer is obtained. This contact is accomplished by a vacuum chuck, an electrostatic chuck, or the like. However, there is a problem in that it is extremely difficult to realize complete contact; further, there is a problem in that the photomask and the wafer are mechanically brought into contact, and protrusions and the like on the front surface of the wafer therefore cause defects in the photomask, which reduces the life of the photomask while at the same time adversely impacting the yield of devices.

[0004]

Accordingly, a liquid (immersion liquid) is filled between the photomask and the wafer as a method to solve the problems caused by a contact exposure system. FIG. 2 shows a wafer

that has been brought into close contact with a projection optical system through an immersion liquid; therein, 1 is the photomask, 2 is an exposure lens that constitutes part of the projection optical system, 3 is the wafer, which is coated by a photoresist 4, 5 is the immersion liquid, which is filled between the exposure lens 2 and the wafer 3, 6 is an irradiation light that irradiates a pattern 7 of a photomask 1 and exposes the photoresist 4, 8 is a holding body that holds the wafer 3, and 9 is a compression coil spring that urges the holding body 8 upward and pushes the wafer 3 against the exposure lens 2 with a prescribed pressure. The shorter the wavelength of the irradiation light 6, the lesser the impact of diffraction, and consequently a laser apparatus, such as an excimer laser, is used as the light source. It is preferable that the immersion liquid 5 has a refractive index approximately the same as the photoresist 4, absorbs little light, and does not dissolve the photoresist 4; normally, pure water is used.

[0005]

PROBLEMS SOLVED BY THE INVENTION

Nevertheless, in a contact exposure apparatus that uses the immersion liquid 5 as discussed above, there is a problem in that unevenness arises in the amount of the irradiation light 6 absorbed by the immersion liquid 5 if there is film thickness unevenness in the immersion liquid 5 itself, which unfortunately leads to portions where the pattern of the contact exposed photoresist 4 is precisely exposed and portions where it is not. Accordingly, to prevent the occurrence of such exposure unevenness, it is preferable to increase the wettability and lower the surface tension of the immersion liquid 5, as well as to reduce a film thickness d1 thereof as much as possible.

[0006]

The present invention considers the problems and needs of the conventional art discussed above, and it is an object of the present invention to provide a contact exposure apparatus that can reduce and prevent exposure unevenness caused by the immersion liquid by reducing the film thickness thereof.

[0007]

MEANS FOR SOLVING THE PROBLEMS

To achieve the abovementioned objects, the present invention is a contact exposure apparatus that brings a wafer, which is coated with a photoresist, into close contact with a projection optical system or a photomask through an immersion liquid, and then transfers a pattern of the photomask to the photoresist by irradiating an irradiation light, wherein a surfactant is mixed into the immersion liquid within a range that does not affect the photoresist.

[0008]

MODE OF OPERATION

In the present invention, the surfactant increases the wettability and reduces the surface tension of the immersion liquid. Accordingly, the film thickness of the immersion liquid is reduced.

[0009]

EMBODIMENTS

The following explains the present invention in detail, based on the embodiments shown in the drawings. FIG. 1 is a cross sectional view of the principle parts of one embodiment of a contact exposure apparatus according to the present invention. Furthermore, constituent parts that are identical to those in FIG. 2 are assigned the same symbol, and the explanations thereof are omitted.

[0010]

The present embodiment describes a case wherein a wafer is brought into close contact with a projection optical system; in this case, a surfactant 11 is mixed into an immersion liquid 5, such as pure water, that is interposed between a wafer 3 and an exposure lens 2, which constitutes part of a photomask projection optical system.

[0011]

Various types of surfactants can be used for the surfactant 11, such as cationic, anionic, and nonionic types, but it is preferable that the surfactant used has a refractive index approximately the same as the immersion liquid 5, absorbs little light, and mixes in within a range that does not dissolve a photoresist 4. In particular, among cationic types, a quaternary ammonium salt is preferable because it has high wettability, has little impact on the resist, and absorbs little light.

[0012]

Thus, in such a constitution, the surfactant 11 enhances wettability by reducing the surface tension of the immersion liquid 5; consequently, it is possible to reduce a film thickness d2 of the immersion liquid 5 ($d2 < d1$), compared with the conventional apparatus shown in FIG. 2, when the wafer 3 pressure contacts the exposure lens 2 at a prescribed pressure; in addition, the lesser the film thickness, the lesser the amount of absorbed light, and therefore it is possible to reduce the unevenness in the absorption of light in proportion to the film thickness, and to reduce and prevent exposure unevenness.

[0013]

EFFECTS OF THE INVENTION

According to the contact exposure apparatus of the present invention as explained above, mixing the surfactant into the immersion liquid reduces the surface tension of the immersion

liquid itself and thereby improves wettability, and it is therefore possible to reduce the film thickness of the immersion liquid. Accordingly, it is possible to reduce the film thickness unevenness and the light absorption of the immersion liquid, which makes it possible to reduce and prevent exposure unevenness caused by the immersion liquid.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a cross sectional view of the principle parts of one embodiment of a contact exposure apparatus according to the present invention.

FIG. 2 is a cross sectional view of the principle parts of a conventional example of a contact exposure apparatus.

EXPLANATION OF SYMBOLS

1	Photomask
2	Exposure lens
3	Wafer
4	Photoresist
5	Immersion liquid
6	Irradiation light
7	Mask
11	Surfactant